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NIXON & VANDERHYE, PC 901 NORTH GLEBE ROAD, 11TH FLOOR ARLINGTON, VA 22203				
			EXAMINER BAREFORD, KATHERINE A	
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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 10/809,681	Applicant(s) SHINGUBARA ET AL.	
	Examiner Katherine A. Bareford	Art Unit 1762	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 26 June 2007.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-7 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-7 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| 1) <input type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08)
Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

The amendment of June 26, 2007 has been received and entered. With the entry of the amendment, claims 1-7 remain pending for examination.

Claim Objections

1. Claim 5 is objected to because of the following informalities: in claim 5, lines 3-4, reference to "selected from the group consisting of" is made, but only one selection is possible. In the amendment of June 26, 2007, only one selection remains possible, "the mixture".

Appropriate correction is required.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

3. Claim 5 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

The June 26, 2007 amendment to claim 5 to provide that the mixture is of hydrofluoric acid, a nitric acid "and a diluted hydrofluoric acid" is new matter. The claim originally provided for the further use of a "diluent of hydrofluoric acid". The original specification, at page 10, lines 14-16, provides using a "diluent which is prepared by diluting a hydrofluoric acid with pure water ten or more times." This results in a specific range of water:hydrofluoric acid in the "diluent". However, "diluted hydrofluoric acid" as claimed can be diluted by any material and by any amount, and thus is not supported by the disclosure as originally filed. Furthermore, the disclosure as originally filed, see the specification at page 6 and 10 describes using "a mixture of hydrofluoric acid and a nitric acid or a diluent of hydrofluoric acid", not both.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

5. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were

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made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

6. Claims 1, 2, 4 and 7 are rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted state of the prior art in view of Kawanoue et al (US 6229211).

The admitted state of the prior art, at pages 1-4 of the specification, teaches a known process for making embedded multilevel interconnects. For example, the process includes forming a hole portion in an insulating layer (page 2, line 25 through page 3, line 7). Then a barrier metal film of TaN is formed on the hole portion walls, by a method such as sputtering (page 3, lines 5-10). An oxide film formed on a surface of the barrier metal film is removed by etching (page 3, lines 5-15). Then, an electroless plating step of immersing the barrier metal film in a plating liquid comprising copper, thereby forming an electroless copper plating film on the barrier metal film occurs (page 3, lines 15-18).

Claim 7: Finally, an electrolytic copper plating step occurs over the electroless copper plating film (which thereby acts as the seed layer for the electrolytic plating) (page 3, lines 18-21).

The admitted state of the prior art teaches all the features of these claims except (1) the element composition ratio of N/Ta (claims 1, 2) and (2) the removal step is such

that the barrier metal film is left in such a manner that it entirely covers the inner wall of the hole portion (claim 4).

However, Kawanoue teaches barrier metal films that can be used when forming embedded multilevel interconnection, where a copper layer is applied over the barrier films. Column 1, lines 5-40, column 8, lines 5-25 and Figures 3B and 3D, for example. A barrier film is applied to a hole portion area of an insulating layer. Figures 3B and 3D, for example, and column 8, lines 5-25. The barrier film can be tantalum nitride, and can be formed by sputtering. Column 3, lines 50-65 and column 8, lines 5-25 and 50-65. The ratio of nitrogen to tantalum (N/Ta) can be 0.87, for example. Figures 3B and 3D, for example, and column 8, lines 5-25 (film 34 or film 38). When copper is applied over the barrier film, the barrier film is provided in such a manner that it entirely covers the inner wall of the hole portion. Figures 3A and 3B and column 7, lines 45-55.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the admitted state of the prior art to use a N/Ta ratio of 0.87, for example, as suggested by Kawanoue with an expectation of desirable protective barrier action, because the admitted state of the prior art teaches the desire to provide TaN films by a method such as sputtering for forming barrier films for embedded multilevel interconnects, and Kawanoue teaches that TaN films provided by a method such as sputtering for forming barrier films for embedded multilevel interconnects can acceptably have a N/Ta ratio of 0.87. Furthermore, it would also have been obvious to modify the admitted state of the prior art to perform the removal

step such that the barrier metal film is left in such a manner that it entirely covers the inner wall of the hole portion when copper coating is performed as suggested by Kawanoue in order to provide a desirable copper plating, because the admitted state of the prior art provides applying a barrier film to hole walls and etching the barrier film (to remove oxide) prior to applying copper and Kawanoue teaches that it is well known when applying a barrier film to hole walls prior to applying copper, to have the barrier film covering all of the hole walls before when applying the copper.

7. Claim 3 is rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted state of the prior art in view of Kawanoue as applied to claims 1, 2, 4 and 7 above, and further in view of Miyamoto (US 6284649).

The admitted state of the prior art in view of Kawanoue teaches all the features of this claim except that the TaN film is formed by plasma nitriding tantalum.

However, Miyamoto teaches a method of forming a tantalum nitride barrier layer to use in semiconductor devices, where the barrier layer is applied in a connection hole and then Cu is applied over the barrier layer. Column 1, line 35 through column 2, line 10. Miyamoto teaches that one way to achieve the tantalum nitride barrier layer is to apply a tantalum layer and then performing plasma nitriding to form the tantalum nitride. Column 10, lines 1-55 and column 9, lines 1-30.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the admitted state of the prior art in view of Kawanoue

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to achieve the tantalum nitride barrier film by applying tantalum and plasma nitriding as suggested by Miyamoto in order to provide a desirable barrier film, because the admitted state of the prior art in view of Kawanoue teaches forming a TaN barrier film onto which copper is to be applied, and Miyamoto teaches that a well known way of achieving such a TaN barrier layer is by applying tantalum and then plasma nitriding.

8. Claims 5-6 are rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted state of the prior art in view of Kawanoue as applied to claims 1, 2, 4 and 7 above, and further in view of Wang et al "Electroless Plating of Copper on Metal-Nitride Diffusion Barriers Initiated by Displacement Plating" (Hereinafter Wang Electroless Article).

The admitted state of the prior art in view of Kawanoue teaches all the features of these claims except the acid system used for the removal of oxide (claim 5) and the reducing agent for the electroless plating (claim 6). The admitted state of the prior art, page 3, lines 10-15, teaches to remove the surface of the barrier film by etching.

However, Wang Electroless Article teaches a method of forming interconnects, where tantalum nitride is used as a barrier material. Page C38. The tantalum nitride is applied to the surface by a process such as sputtering. Page C38, column 2. Then the substrate with TaN is etched with HF: HNO₃:H₂O solution (hydrofluoric acid: nitric acid: and water – a diluent of hydrofluoric acid). Page C38, column 2 (the use of the water would also provide that diluted hydrofluoric acid is present). This removes the

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oxide from the surface. Pages C38-C39 (see paragraph bridging pages). Then electroless copper plating is performed. Page C38, column 2. Moreover, Wang Electroless Article teaches that the reducing agent used for the electroless copper plating bath can be glyoxylic acid. Page C38, column 2.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the admitted state of the prior art in view of Kawanoue to etch treat the tantalum nitride film by immersing in a solution of hydrofluoric acid, nitric acid, and a diluent of hydrofluoric acid to remove oxide as suggested by Wang Electroless Article in order to provide a desirable barrier film, because the admitted state of the prior art in view of Kawanoue teaches forming a TaN barrier film onto which copper is to be applied and etching before copper plating, and Wang Electroless Article teaches that a well known way of achieving such etching for a TaN barrier layer before copper plating is by applying solution treating, which would suggest immersion to apply the solution, with solution of hydrofluoric acid, nitric acid and a diluent of hydrofluoric acid to remove oxide. The use of the diluent of hydrofluoric acid and the present^{ce} of hydrofluoric acid would also provide that "diluted hydrofluoric acid" would be present, and therefore it would have been obvious to one of ordinary skill in the art that rather than "water" in the mixture "diluted hydrofluoric acid" (diluted in water) would provide the same results, because both water and hydrofluoric acid would be present as already required by the mixture of Wang Electroless Article. It would further have been obvious to modify the admitted state of the prior art in view of

Kawanoue to use glyoxylic acid as the reducing agent for the copper electroless plating bath as suggested by Wang Electroless Article in order to provide a desirable copper plating, because the admitted state of the prior art in view of Kawanoue teaches forming a TaN barrier film onto which copper is applied by electroless plating, and Wang Electroless Article teaches that a well known way of achieving such electroless plating on a TaN barrier film is by using glyoxylic acid as the reducing agent for the electroless plating bath.

9. Claim 5 is rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted state of the prior art in view of Wang et al "Suppression of native oxide growth in sputtered TaN films and its application to Cu electroless plating" (Hereinafter Wang Suppression Article).

The admitted state of the prior art, at pages 1-4 of the specification, teaches a known process for making embedded multilevel interconnects. For example, the process includes forming a hole portion in an insulating layer (page 2, line 25 through page 3, line 7). Then a barrier metal film of TaN is formed on the hole portion walls, by a method such as sputtering (page 3, lines 5-10). An oxide film formed on a surface of the barrier metal film is removed by etching (page 3, lines 5-15). Then, an electroless plating step of immersing the barrier metal film in a plating liquid comprising copper, thereby forming an electroless copper plating film on the barrier metal film occurs (page 3, lines 15-18).

Claim 7: Finally, an electrolytic copper plating step occurs over the electroless copper plating film (which thereby acts as the seed layer for the electrolytic plating) (page 3, lines 18-21).

The admitted state of the prior art teaches all the features of these claims except (1) the element composition ratio of N/Ta (claims 1), (2) the acid system used for the removal of oxide (claim 5).

However, Wang Suppression Article teaches a method of forming interconnects, where tantalum nitride is used as a barrier material. Page 4697. The tantalum nitride is applied to the surface by a process such as sputtering. Page 4697, column 2. Then the substrate with TaN is etched in HF: HNO₃:H₂O solution (hydrofluoric acid: nitric acid: and water - a diluent of hydrofluoric acid). Page 4700, column 1 (the use of the water would also provide that diluted hydrofluoric acid is present). Then electroless copper plating is performed: Page 4700, column 1. Optimum results are reached when the applied barrier film has a N/Ta ratio of 1.25. Page 4700, column 1 and page 4701, column 1. Moreover, Wang Suppression Article teaches that the reducing agent used for the electroless copper plating bath can be glyoxylic acid. Page 4698, column 1.

It would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the admitted state of the prior art to use a N/Ta ratio of 1.25, for example, as suggested by Wang Suppression Article with an expectation of desirable protective barrier action, because the admitted state of the prior art teaches the desire to provide TaN films by a method such as sputtering for forming barrier films for

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embedded multilevel interconnects, and Wang Suppression Article teaches that TaN films provided by a method such as sputtering for forming barrier films for embedded multilevel interconnects can optimally have a N/Ta ratio of 1.25. Furthermore, it would have been obvious to modify the admitted state of the prior art to etch treat the tantalum nitride film by immersing in a solution of hydrofluoric acid, nitric acid, and a diluent of hydrofluoric acid to remove oxide as suggested by Wang Suppression Article in order to provide a desirable barrier film, because the admitted state of the prior art teaches forming a TaN barrier film onto which copper is to be applied and etching before copper plating, and Wang Suppression Article teaches that a well known way of achieving such etching for a TaN barrier layer before copper plating is etching in solution, which would suggest immersion to apply the solution, with solution of hydrofluoric acid, nitric acid and a diluent of hydrofluoric acid to remove oxide. The use of the diluent of hydrofluoric acid and the presence of hydrofluoric acid would also provide that "diluted hydrofluoric acid" would be present, and therefore it would have been obvious to one of ordinary skill in the art that rather than "water" in the mixture "diluted hydrofluoric acid" (diluted in water) would provide the same results, because both water and hydrofluoric acid would be present as already required by the mixture of Wang Suppression Article.

10. While a translation of the foreign priority papers has been made of record on June 26, 2007 in accordance with 37 CFR 1.55, it does not overcome the rejection in

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regard to claim 5, as claim 5 now requires using "a mixture of a hydrofluoric acid, a nitric acid and a diluted hydrofluoric acid", while the foreign priority document only teaches using "mixture of a hydrofluoric acid and a nitric acid or a diluent of a hydrofluoric acid" (see claim 5, page 1 of translation, and paragraph [0027] of translation), and therefore, does not support claim 5 as worded.

Response to Arguments

11. Applicant's arguments filed June 26m 2997 have been fully considered but they are not persuasive.

(A) As to the rejection of claims 1+ under 35 USC 103 using the admitted state of the prior art in view of Kawanoue, applicant argues that the present invention prevents development of voids during electroless plating where a barrier metal film is immersed in a plating liquid, but on the other hand, Kawanoue using a Cu damascene interconnect layer 17, and does not use an electroless plating process for forming the embedded Cu layer. Therefore, according to applicant, there is no motivation and/or suggestion in Kawanoue for preventing the formation of voids, and therefore, it is not obvious to those skilled in the art to modify the admitted state of the art to use an particular N/Ta ratio which may be shown in Kawanoue.

The Examiner has reviewed these arguments, however, the rejection is maintained. First, applicant argues that their invention prevents voids. However, this is not claimed. Although the claims are interpreted in light of the specification,

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limitations from the specification are not read into the claims. See *In re Van Geuns*, 988 F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993). The only question is--when using a tantalum and nitrogen containing barrier film would using the claimed N/Ta ratio be suggested. The Examiner has provided Kawanoue to provide the suggestion of using such a ratio. Applicant has argued that Kawanoue does not provide the electroless plating, so there is no motivation and/or suggestion for the preventing the formation of voides, and thus one of skill in the art would not be suggested to use an particular N/Ta ratio as shown in Kawanoue. However, the Examiner notes that the rejection uses the admitted state of the prior art as the primary reference, and as discussed in the rejection above, this reference teaches both the electroless plating of copper and the sputtering application of tantalum and nitrogen in the form of tantalum nitride films as the barrier metal film underlying the copper plating. The Examiner has provided Kawnoue as providing that, as discussed in the rejection above, sputtered tantalum nitride films barrier metal films over which copper is to be applied can desirably have an N/Ta ratio of 0.87. It would be suggested to use such an N/Ta ratio in the process of the admitted state of the prior art in order to provide a desirable metal barrier film protective action, as discussed in the rejection above. It is not required that the references teach that this usage is for preventing the formation of voids, because (1) it is not claimed as discussed above, and (2) furthermore, even if the prevention of voids was claimed, the fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for

patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985).

(B) As to the rejection of claims 1+ under 35 USC 103 using the admitted state of the prior art in view of Wang Suppression Article, applicant argues that these rejections are overcome by the simultaneous filing of a verified English translation of Applicant's priority document.

The Examiner has withdrawn the rejection of claims 1, 3, 6 and 7 that used Wang Suppression Article, as the features of these claims were supported by the English translation of Applicant's priority document. However, the rejection of claim 5 remains, because claim 5 as now worded is not supported by the English translation of Applicant's priority document. Claim 5 now requires using "a mixture of a hydrofluoric acid, a nitric acid and a diluted hydrofluoric acid", while the foreign priority document only teaches using "mixture of a hydrofluoric acid and a nitric acid or a diluent of a hydrofluoric acid" (emphasis added) (see claim 5, page 1 of translation, and paragraph [0027] of translation), and therefore, does not support claim 5 as worded.

Conclusion

12. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).


A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Katherine A. Bareford whose telephone number is (571) 272-1413. The examiner can normally be reached on M-F(6:00-3:30) with the First Friday Off.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Timothy Meeks can be reached on (571) 272-1423. The fax phone numbers for the organization where this application or proceeding is assigned are (571) 273-8300 for regular communications and for After Final communications.

Other inquiries can be directed to the Tech Center 1700 telephone number at (571) 272-1700.

Furthermore, information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).


KATHERINE BAREFORD
PRIMARY EXAMINER